DY 55: Dynamics and Chaos in Many-Body Systems II (joint session DY/TT)

Time: Friday 9:30–12:30 Location: MOL 213

DY 55.1 Fri 9:30 MOL 213

Towards a more fundamental understanding of eigenstate thermalization — •Tobias Hofmann, Tobias Helbig, Ronny Thomale, and Martin Greiter — Institut für Theoretische Physik und Astrophysik, Universität Würzburg, 97074 Würzburg, Germany

We explore several venues how eigenstate thermalization may be understood on a more fundamental level. In particular, we report on extensive numerical work in spin systems with random interactions, where a small subsystem is subject to thermalization. We discuss possible directions towards an understanding of our numerical results.

DY 55.2 Fri 9:45 MOL 213

Spectral Response of Disorder-Free Localized Lattice Gauge Theories — •Nilotpal Chakraborty[1], Markus Heyl[1,2], Petr Karpov[1], and Roderich Moessner[1] — [1]Max Planck Institute for Physics of Complex Systems, Dresden — [2]University of Augsburg

We show that certain lattice gauge theories exhibiting disorder-free localization have a characteristic response in spatially averaged spectral functions: a few sharp peaks combined with vanishing response in the zero frequency limit. This reflects the discrete spectra of small clusters of kinetically active regions formed in such gauge theories when they fragment into spatially finite clusters in the localized phase due to the presence of static charges. We obtain the transverse component of the dynamic structure factor, which is probed by neutron scattering experiments, deep in this phase from a combination of analytical estimates and a numerical cluster expansion. We also show that local spectral functions of large finite clusters host discrete peaks whose positions agree with our analytical estimates. Further, information spreading, diagnosed by an unequal time commutator, halts due to real space fragmentation. Our results can be used to distinguish the disorder-free localized phase from conventional paramagnetic counterparts in those frustrated magnets which might realize such an emergent gauge theory.

DY 55.3 Fri 10:00 MOL 213

Chaos in the three-site Bose-Hubbard model - classical vs quantum — •Goran Nakerst[1] and Masudul Haque[1,2] — [1]Institut für Theoretische Physik, Technische Universität Dresden, D-01062 Dresden, Germany — [2]Max-Planck-Institut für Physik komplexer Systeme, D-01187 Dresden, Germany

We consider a quantum many-body system - the Bose-Hubbard system on three sites - which has a classical limit, and which is neither strongly chaotic nor integrable but rather shows a mixture of the two types of behavior. We compare quantum measures of chaos (eigenvalue statistics and eigenvector structure) in the quantum system, with classical measures of chaos (Lyapunov exponents) in the corresponding classical system. As a function of energy and interaction strength, we demonstrate a strong overall correspondence between the two cases. In contrast to both strongly chaotic and integrable systems, the largest Lyapunov exponent is shown to be a multi-valued function of energy.

DY 55.4 Fri 10:15 MOL 213

Many-Body Dwell-time and Density of States — •Georg Maier, Carolyn Echter, Juan-Diego Urbina, and Klaus Richter — Universität Regensburg, Regensburg, Germany

Many body systems with a large number of degrees of freedom are usually described by statistical physics on the theoretical side while experiments usually relay on scattering (e.g. particle physics). Is it possible to relate scattering and statistical physics, or to measure scattering-related observables which directly relate to quantities of statistical physics? At least for single particle systems a close relation exists between the well known Wigner-Smith delay time in scattering theory and the density of states of the scattering system.

I will present a novel ansatz relating a many-body version of dwell-/Wigner-Smith delay time and many body density of states based on the famous Birman-Krein-Friedel-Loyd formula connecting scattering theory and statistical observales in the many-body context. This formalism could provide answers to a wide variety of interesting questions, e.g. can we observe the effect of interactions (or even the emergence of chaos) through the lens of the dwell-time? Another interesting point is the roll of particle statistics on dwell-time meaning e.g. does it take longer for a particle to leave a fermionic or bosonic system?. I will present our analytical and numerical results on these questions.

DY 55.5 Fri 10:30 MOL 213

Dynamical correlations and domain wall relocalisation in transverse field Ising chains — •Philippe Suchsland[1], Benoît Douçot[2], Vedika Khemani[3], and Roderich Moessner[1] — [1]Max Planck Institute for the Physics of Complex Systems, Nöthnitzer Str. 38, 01187 Dresden, Germany — [2]LPTHE, UMR 7589, CNRS and Sorbonne Université, 75252 Paris Cedex 05, France — [3]Department of Physics, Stanford University, Stanford, California 94305, USA

We study order parameters and out-of-time-ordered correlators (OTOCs) for a wide variety of transverse field Ising chains: classical and quantum, clean and disordered, integrable and generic. The setting we consider is that of a quantum quench. We find a remarkably rich phenomenology, ranging from stable periodic to signals decaying with varying rates. This variety is due to a complex interplay of dynamical constraints (imposed by integrability and symmetry) which thermalisation is subject to. In particular, a process we term dynamical domain wall relocalisation provides a long-lived signal in the clean, integrable case, which can be degraded by the addition of disorder even without interactions. Our results shed light on a proposal to use an OTOC specifically as a local dynamical diagnostic of a quantum phase transition even when evaluated in a state with an energy density corresponding to the paramagnetic phase.

15 min. break

DY 55.6 Fri 11:00 MOL 213

Time evolution at the quantum-critical point of the sawtooth chain — •Jannis Eckseler, Florian Johannesmann, and Jürgen Schnack — Fakultät für Physik, Universität Bielefeld, Postfach 100131, D-33501 Bielefeld, Germany

It is known for the antiferromagnetic sawtooth chain with Heisenberg interactions to develop a flat band at the quantum-critical point of $J_1 = 2J_2$, where J_1 is the exchange interaction between nearest neighbors and J_2 the interaction at the base of the triangles [1]. We investigate the time evolution of several observables of the sawtooth chain, especially near that point and in particular in view of their equilibration properties. [1] J. Schulenburg, A. Honecker, J. Schnack, J. Richter, H.-J. Schmidt, Phys. Rev. Lett. 88 (2002) 167207

DY 55.7 Fri 11:15 MOL 213

Quantum Noise as a Symmetry-Breaking Field — •Paul McClarty[1], Beatriz Dias[2], Domagoj Perkovic[3], Masudul Haque[4], and Pedro Ribeiro[5] — [1]MPI PKS, Dresden, Germany — [2]TU Munich, Garching, Germany — [3]Cavendish Lab, University of Cambridge, UK — [4]TU Dresden, Germany — [5]IST, Lisbon, Portugal

We investigate the effect of quantum noise on the measurement-induced quantum phase transition in monitored random quantum circuits. Using the efficient simulability of random Clifford circuits, we find that the transition is broadened into a crossover and that the phase diagram as a function of projective measurements and noise exhibits several distinct regimes. We show that a mapping to a classical statistical mechanics problem accounts for the main features of the random circuit phase diagram. The bulk noise maps to an explicit permutation symmetry breaking coupling; this symmetry is spontaneously broken when the noise is switched off. These results have implications for the realization of entanglement transitions in noisy quantum circuits.

DY 55.8 Fri 11:30 MOL 213

Finite-size prethermal behavior at the chaos-to-integrable transition — •Johannes Dieplinger[1] and Soumya Bera[2] — [1]Institute of Theoretical Physics, University of Regensburg, D-93040 Germany — [2]Department of Physics, Indian Institute of Technology Bombay, Mumbai 400076, India

We investigate the dynamics of the complex Sachdev-Ye-Kitaev model complemented with a single particle hopping term, leading to a chaos-to-integrable transition of the eigenstates. We determine the dynamics close to the transition via the density-density correlator, where we observe a prethermal plateau in the ergodic phase. This indicates a finite time localised behavior up to an interaction-dependent thermalization time scale. This time scale is quantified as $t_{th} \propto 2^{\alpha/\sqrt{\lambda}}$ as a function of the relative interaction strength λ. The results are validated by investigating the time-dependent structure of the time-evolved wave functions in the Fock space.

DY 55.9 Fri 11:45 MOL 213

Quasiparticle Description of Entanglement Growth — •Molly Gibbins, Bruno Bertini, and Adam Smith — University of Nottingham

The quasiparticle picture of entanglement is a novel way to describe a feature unique to quantum many-body systems. Recent research has found excellent agreement of this description with numeric results: a description that had been shown to hold for the general family of Rényi entanglement entropies, for different classes of quench and different geometries of the boundary across which entanglement develops.

The aim of this project is to develop a quasiparticle description of the entanglement growth in free-fermionic systems with translational invariance in both 1D and 2D. The propagation of quasiparticles across this cut will respect this translational invariance and it is expected that the entanglement generated between these particles will be in very good agreement with the exact solution for these systems.

DY 55.10 Fri 12:00 MOL 213

Excitation Transport in Molecular Aggregates with Thermal Motion — •Ritesh Pant and Sebastian Wüster — Indian institute of science education and research, Bhopal, India

Molecular aggregates can under certain conditions transport electronic excitation energy over large distances due to the long range dipole-dipole interactions. These interactions are also the characteristics of Rydberg aggregates which have been proved as the quantum simulators for molecular aggregates. An idea that naturally arises in Rydberg aggregates, is adiabatic excitation transport through atomic motion, where slow motion of the atoms combined with excitation transport can result in efficient and guided transport of the excitation from one end of an atomic chain to the other. Based on the analogy between Rydberg and Molecular aggregates, in ref. [1] we explore whether the adiabatic excitation transport can play a functional role in molecular aggregates in the absence of intra-molecular vibrations. But because the transport is partially adiabatic and because it involves transitions between non-eigenstates, it is challenging to estimate the adiabaticity of transport in molecular aggregates. Hence, in ref [2] we established a measure to quantify the adiabatic character of quantum transitions in general. Next, the effect of intramolecular vibrations is included by extending our calculation for excitation transport to an open-quantum-system technique [3].

[1] R. Pant and S. Wüster, Physical Chemistry Chemical Physics 22, 21169 (2020). [2] R. Pant, et al., https://arxiv.org/abs/2007.10707. [3] R. Pant, et al., (Manuscript in preparation)

DY 55.11 Fri 12:15 MOL 213

Tailoring the Phonon Environment of Embedded Rydberg Aggregates — •Sidharth Rammohan[1], Sebastian Wüster[1], and Alexander Eisfeld[2] — [1]IISER Bhopal, Madhya Pradesh, India — [2]MPIPKS, Dresden, Germany

State-of-the-art experiments can controllably create Rydberg atoms inside a Bose-Einstein condensate (BEC) such that the Rydberg electron orbital volume contains many neutral atoms, which can be tuned, resulting in electron-atom scattering events [1]. In my talk, I will discuss the physics of the interaction and corresponding dynamics of a single or multiple Rydberg atoms in two internal electronic states embedded inside a BEC, to assess their utility for controlled studies of decoherence and quantum simulations of excitation transport similar to photosynthetic light-harvesting. We initially developed a theoretical framework to calculate the open quantum system input parameters for a single Rydberg atom, possibly in two internal states, in BEC and then for a chain of Rydberg atoms, forming an aggregate [2]. The electron-atom interactions lead to Rydberg-BEC coupling, creating phonons in the BEC. Using the spin-boson model with the calculated parameters, we then examine the decoherence and the Non-Markovian features of a Rydberg atom in a superposition, resulting from the interaction with the environment [3]. The scenario with a single Rydberg atom is then extended to the aggregate case, allowing us to set up dynamics similar to those found in light-harvesting complexes. Ref:1. J. B. Balewski, et.al; Nature 502 664 (2013).2. S. Rammohan, et.al; PRA 103, 063307 (2021).3. S. Rammohan, et.al; PRA 104, L060202 (2021).